Indian J. Phys. **66B** (1), 77–79 (1992)

The conductivity tensor considering wind effect

R Misra
P K College, Contai, Midnapore, West Bengal, 721 401, India
and
K C Kamila*
Ramnagar College, Depal, Midnapore, West Bengal, 721 453, India

Received 3 December 1990, accepted 5 September 1991

Abstract : It is known that the movement of ionospheric constituents around magnetic field lines by tidal winds generate e.m.f and current producing polarization electric fields. In this note attempt has been made to deduce the conductivity tensor from considerations of electrostatic field.

Keywords : Conductivity tensor, differential motion of ions and electrons, wind effect

PACS Nos : 92.60 Gn, 92.60 Ta, 94.20. Ss

It is found in literatures (Price 1968, Forbes 1981, Datta and Chakravarty 1983) that polarization electric fields are generated instantaneously to form the currents caused by e.m.f. produced due to the movement of ionospheric constituents around magnetic field lines by tidal winds. It is shown (Tarpley 1970 and Raghavarao and Anandarao, 1987) that the day time Sq. electric field has two components. As the winds are mainly horizontal, the dynamo action is most effective at mid-latitude regions where the earth's magnetic field lines are almost vertical as mentioned by Raghavarao and Anandarao (1987).

Maxwell's equations demand the presence of the vertical current, which was absent in the model of Baker and Martyn (1953). However, Maeda (1977) considered the electrostatic field as generated by the differential motion of ions and electrons and a hydrostatic equillibrium has been assumed to exist in vertical direction.

In this note an attempt has been made to deduce the conductivity tensor starting from the considerations of Baker and Martyn (1953) and to show that the tensor is equivalent to that of Maeda (1977) although some considerations are different in the two cases.

Now, the general equation for current density as in Baker and Martyn (1953) and Raghavarao and Anandarao (1987) could be written as :

*For all correspondences.

$$J = \sigma_0 E'_{11} + \sigma_1 E'_{\perp} + \sigma_2 \left(\hat{h} \times E'\right) \tag{1}$$

where $E' = E + W \times B$ includes the effects of wind, other parameters are as defined in the above works. $W \times B$ = wind induced Lorentz field due to wind velocity W. Here σ_0, σ_1 and σ_2 are respectively the parallel, Pedersen and Hall conductivities which remain same when wind induced Lorentz field is active since this field is much small as compared to global dynamo field and has small effect (Raghavarao and Anandarao 1987). Ex, Ey being the primary electric fields around the magnetic equator, Ez, the polarization electric field and the components of E' i.e. $E'x$, $E'y$, $E'z$ are along X (South), Y (positive east ward) and Z (positive upwards) respectively.

Thus

$$E'_{11} = \left(E'_x \cos^2 I + E'_z \cos I \sin I\right) \hat{i} + \left(E'_x \cos I \sin I + E'_z \sin^2 I\right) \tag{2}$$

and

$$E'_{\perp} = \left(E'_x \sin^2 I - E'_z \cos I \sin I\right) \hat{i} + E'_y \hat{j} + \left(- E'_x \cos I \sin I + E'_z \cos^2 I\right) \hat{k} \tag{3}$$

with

$$\hat{h} \times E' = E'_y \sin I \, \hat{i} - \left[E'_x \sin I - E'_z \cos I \right] \hat{j} - E'_y \cos I \, \hat{k} \tag{4}$$

where I is the dip angle.

Using eqs. (2), (3) and (4) the components of J become

$$J_x = (\sigma_0 c^2 + \sigma_1 s^2) E'_x + \sigma_2 s E'_y + (\sigma_0 - \sigma_1) sc E'_z \tag{5}$$

$$J_y = - \sigma_2 s E'_x + \sigma_1 E'_y + \sigma_2 c E'_z \tag{6}$$

$$J_z = (\sigma_0 - \sigma_1) sc E'_x - \sigma_2 c E'_y + (\sigma_0 s^2 + \sigma_1 c^2) E'_z \tag{7}$$

where $s = \sin I$ and $c = \cos I$.

Thus

$$(\sigma) = \begin{pmatrix} \sigma_0 c^2 + \sigma_1 s^2 & \sigma_2 s & (\sigma_0 - \sigma_1) sc \\ - \sigma_2 s & \sigma_1 & \sigma_2 c \\ (\sigma_0 - \sigma_1) sc & -\sigma_2 c & \sigma_0 s^2 + \sigma_1 c^2 \end{pmatrix} \tag{8}$$

the conductivity tensor is the same as that of Maeda (1977) although the approach is different.

Acknowledgments

The authors are grateful to Prof B Chakravarty, Head of the Department. of Physics, Indian Institute of Technology, Kharagpur, for his kind discussions about the matter.

References

Baker W G and Martyn D F 1953, *Phil Trans. Roy. Soc. London* **246A** 281

Datta J B and Chakravarty B 1983 *Indian J. Phys* **57B** 457

Forbes J M 1981 *Rev Geophys Space Phys.* **19** 469

Maeda K 1977 *J Atoms. Terr Phys.* **39** 1041

Price A T 1968 *Geophys. J. Roy. Astronm Soc* **15** 93

Raghavarao R and Anandarao B G 1987 *Indian J Radio and Space Phys* **16** 54

Tarpley J D 1970 *Planet Space Sci* **18** 1091